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FATIGUE STRENGTH OF JOINTS MADE BY FRICTION WELDING

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Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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13. ABSTRACT

Weldments made of dissimilar metals were tested for fatigue strength. Specimens 12 mm diameter and prepared from the steel R18 and 45 were investigated. Fatigue tests were made on specimens obtained by friction welding and by electrocontact welding by fusion. Comparison of these results shows that welding by friction is not inferior in strength to electrocontact welding by the fusion method and that both methods give practically equally strong weldments.
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Б	б	*Б*	*б*	B, b	С	с	*С*	*с*	S, s
В	в	*В*	*в*	V, v	Т	т	*Т*	*т*	T, t
Г	г	*Г*	*г*	G, g	У	у	*У*	*у*	U, u
Д	д	*Д*	*д*	D, d	Ф	ф	*Ф*	*ф*	F, f
Е	е	*Е*	*е*	Ye, ye; E, e*	Х	х	*Х*	*х*	Kh, kh
Ж	ж	*Ж*	*ж*	Zh, zh	Ц	ц	*Ц*	*ц*	Ts, ts
З	з	*З*	*з*	Z, z	Ч	ч	*Ч*	*ч*	Ch, ch
И	и	*И*	*и*	I, i	Ш	ш	*Ш*	*ш*	Sh, sh
Й	й	*Й*	*й*	Y, y	Щ	щ	*Щ*	*щ*	Shch, shch
К	к	*К*	*к*	K, k	Ъ	ъ	*Ъ*	*ъ*	"
Л	л	*Л*	*л*	L, l	Ы	ы	*Ы*	*ы*	Y, y
М	м	*М*	*м*	M, m	Ь	ь	*Ь*	*ь*	'
Н	н	*Н*	*н*	N, n	Э	э	*Э*	*э*	E, e
О	о	*О*	*о*	O, o	Ю	ю	*Ю*	*ю*	Yu, yu
П	п	*П*	*п*	P, p	Я	я	*Я*	*я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

FATIGUE STRENGTH OF JOINTS MADE BY FRICTION WELDING

A. I. Khristoforov, A. G. Seleznev,
I. L. Tsymbal, and A. K. Balyuk

Friction welding is a promising technological process of joining both similar and dissimilar metals. Possessing a number of substantial advantages in comparison with electrocontact arc butt welding (high productivity and economy, automation, relative simplicity of equipment, safety, etc.), it all the more supersedes the latter in the production of the core-type cutter, whose working section is made of expensive high-speed steel (R9, R18), and whose shank is made of structural steel (40Kh, 45, etc.), which has adequate strength and ductility.

Quality studies of weld joints showed that the friction welding of milling cutter blanks provides the required strength, which is not inferior in strength to a weld joint made by electrocontact butt welding. This quality has most often been evaluated in terms of the results of static, tensile, bending, and torsion tests. However, many parts of critical machines and mechanisms, as well as the cutter, operate under conditions of impact load and repeated variable load action and break down as a result of fatigue. The question of the fatigue strength of joints made by friction welding has been insufficiently studied.

The nonuniformity of mechanical properties at the junction of the two welded materials can serve, in a specified stage of variable loading, as a stress concentrator. A metal which has a high plasticity can escape the region of elastic deformations as a result of the accumulation of irreversible elasto-plastic strains in the fatigue process earlier than the plastic material. On the other hand, limiting the deformation of a metal with a low yield point near their fusion junction can cause a rigid volumetric stressed state in a soft material. This can retard development at this location of plastic deformations and thereby reduce the unfavorable effect of the sharp change in mechanical properties [1-3].

At the Kharkov Polytechnical Institute phenomena which occur during friction welding were investigated; special experiments were conducted on the fatigue strength of welds of dissimilar metals, the results of which are given in this article.

An investigation was conducted on specimens 12 mm in diameter made of steel R18 and 45, whose mechanical properties, as is known, sharply differ from each other. They were made by employing friction welding on an experimental unit developed by the metal technology department with operating conditions: 740 revolutions per minute; specific pressure during heating and during peening kept constant and equal to 10.5 kgf/mm^2. After welding, part of the specimens were subjected to metallographic examination, the other – to mechanical fatigue strength tests.

The metallographic examinations were conducted in two sets: study of the macro- and the microstructure of weld joints and determination of the macro- and microhardness.

The different mechanical properties of the metals being welded cause plastic deformation, which is asymmetrical relative to the surface of the butt joint. The blank made of high-speed steel is more heat resistant than one made of steel 45 and, possessing greater hardness, remains virtually undeformed, while the blank made of carbon steel undergoes considerable deformation, as indicated by the size of the flash.

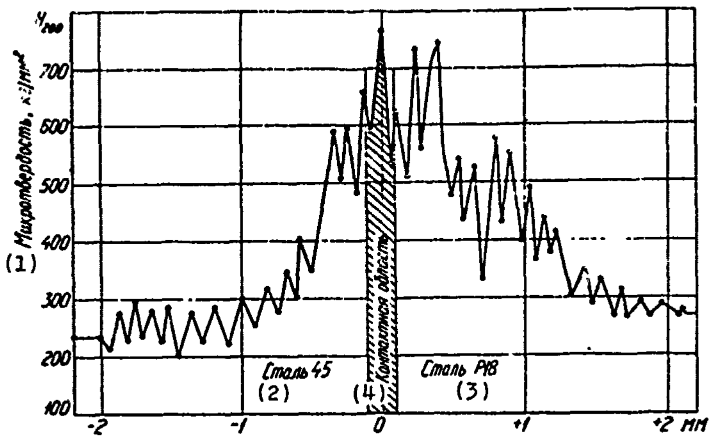

Fig. 1. Microhardness of the weld joint.
KEY: (1) Microhardness, kg/mm^2; (2) Steel 45; (3) Steel R18; (4) Contact region.

Microstructural analysis made it possible to determine the boundaries and the nature of the metal structure. A fine-grained structure and partial blending of the steels being welded occur in the zone of the butt joint.

Measurement of the macrohardness in the welded joint showed a considerable rise in hardness in the weld zone in comparison with the hardness of the base metal. The rise in hardness is caused by the formation of a heat-affected zone as a result of thermal effects, as well as by the complex plastic deformation of the metal during the welding process.

Microhardness in the weld area was measured on the PMT-3 device every 0.05 mm. The nature of the change in microhardness is shown in Fig. 1.

Since the partial mixing of the steels being welded occurs in the weld zone, a significant scatter in the individual measurements is observed during the determination of microhardness in this zone.

The joints prepared by friction welding were subjected to fatigue strength testing. The tests were conducted on an 8-spindle, cantilever-type machine.

The test specimens were made in the shape and dimensions established by ГОСТ 2860-45 [ГОСТ = GOST = All Union State Standard] for mechanical tests (Fig. 2). A specimen is fastened by one end in the chuck of the machine and a bending moment, which is caused by the suspension of a specified load, is applied to the other end. The tests were conducted during alternating circular bending with 2700 loadings per minute. The results of the tests are given in Fig. 2.

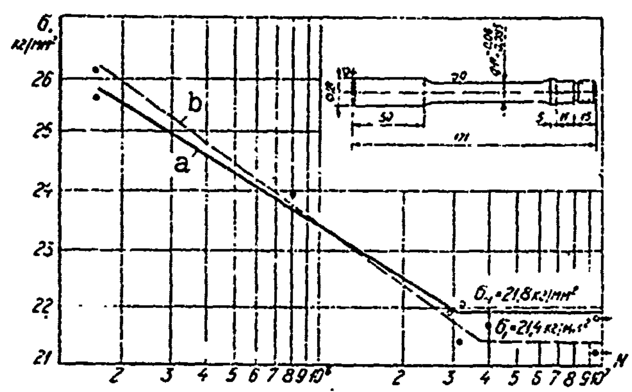

Fig. 2. Fatigue curves of the specimens made by friction welding (a) and by electrocontact flash welding (b). [кг/мм^2 = kg/mm^2]

The use for the tests of multispindle machines made it possible to simultaneously conduct fatigue tests on specimens prepared by friction welding and by electrocontact flash welding.

For comparison Fig. 2 (curve b) gives the test results for the specimens prepared by electrocontact flash welding on a 75 kVA ASIF-type machine.

A comparison of these results shows that friction welding is not inferior in terms of strength to the electrocontact welding method and that both methods produce joints of virtually the same strength.

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